FIG.1

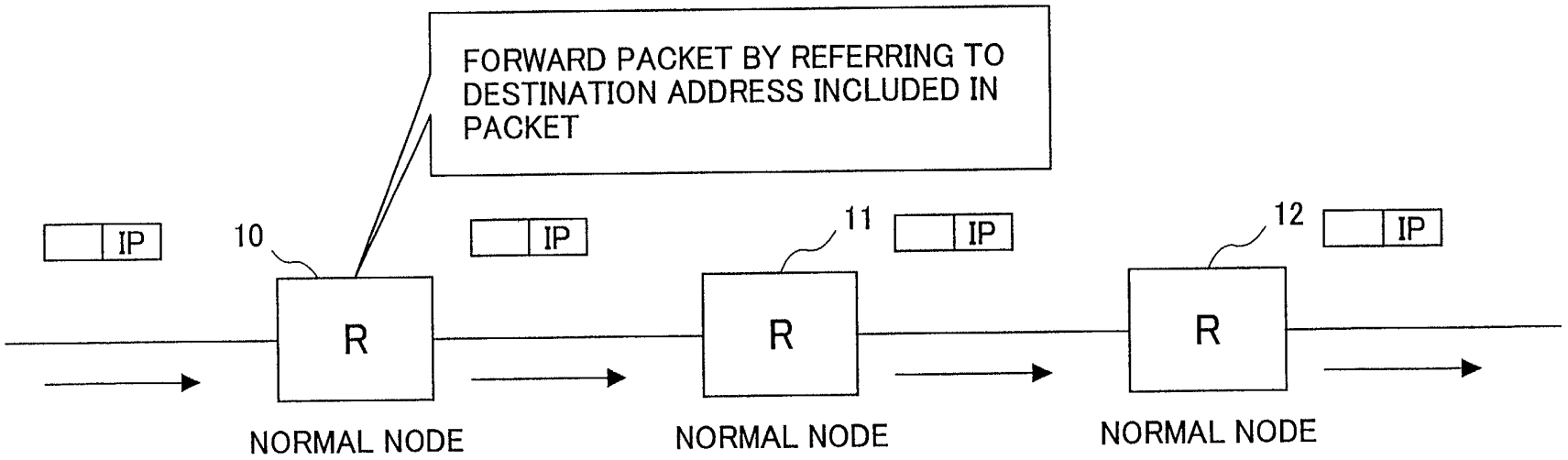

FORWARD PACKET BY REFERRING TO DESTINATION ADDRESS INCLUDED IN PACKET
IP
10
IP
11
IP
12
IP
R
R
R
NORMAL NODE
NORMAL NODE
NORMAL NODE

FIG.2

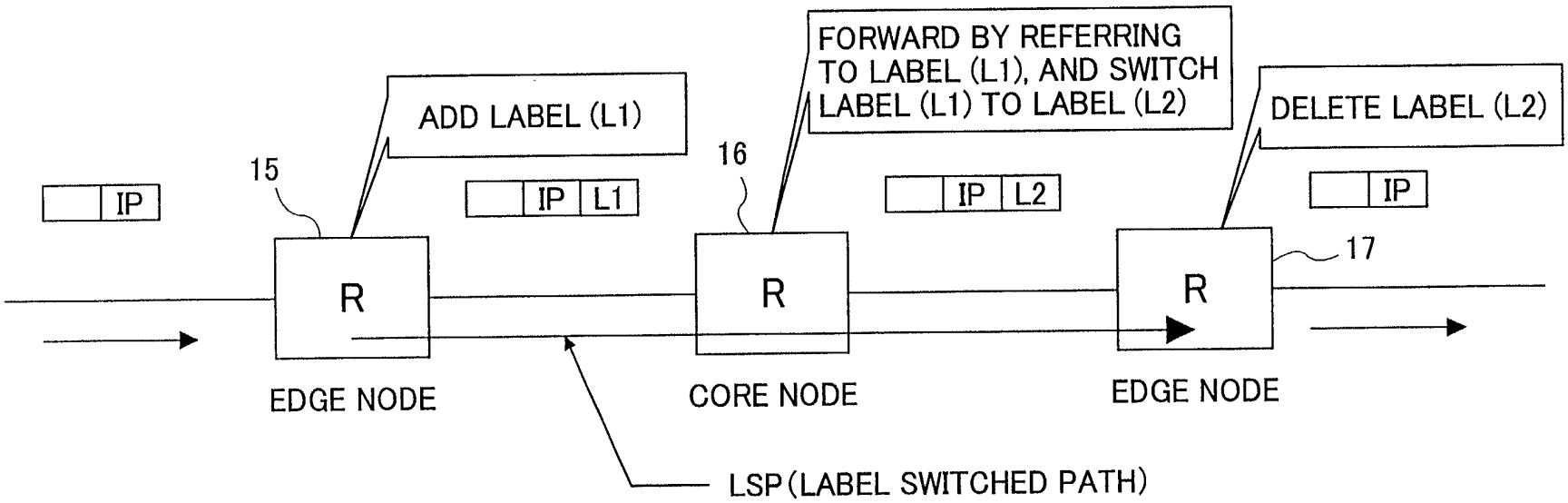

IP
15
ADD LABEL (L1)
IP L1
FORWARD BY REFERRING TO LABEL (L1), AND SWITCH LABEL (L1) TO LABEL (L2)
16
IP L2
DELETE LABEL (L2)
IP
17
R
R
R
EDGE NODE
CORE NODE
EDGE NODE
LSP (LABEL SWITCHED PATH)

FIG.3

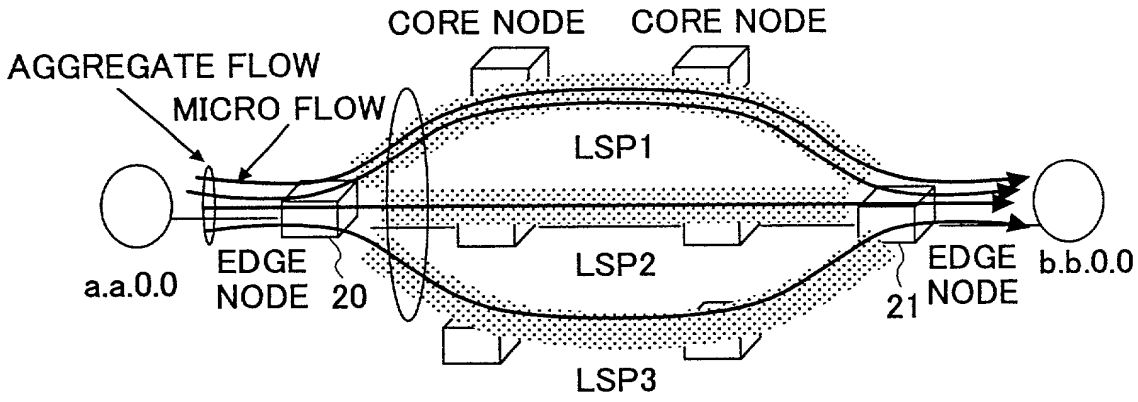

CORE NODE
CORE NODE
AGGREGATE FLOW
MICRO FLOW
LSP1
LSP2
LSP3
a.a.0.0
EDGE NODE
20
21
EDGE NODE
b.b.0.0

FIG.4

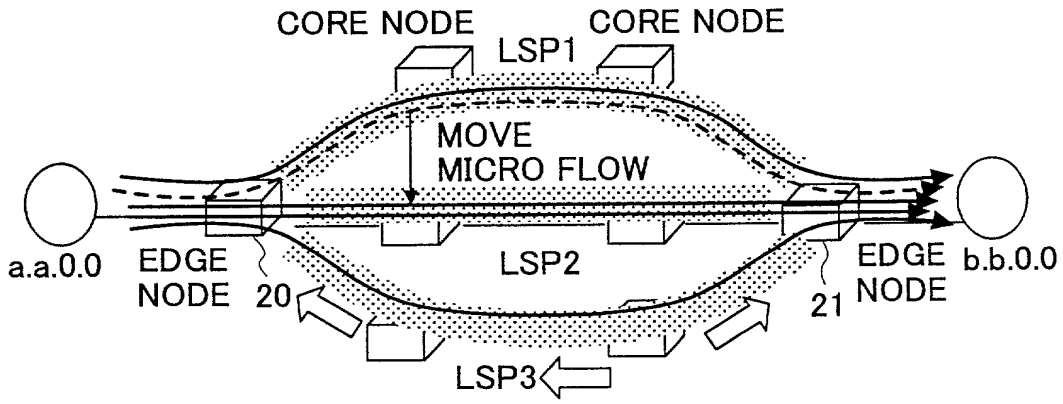
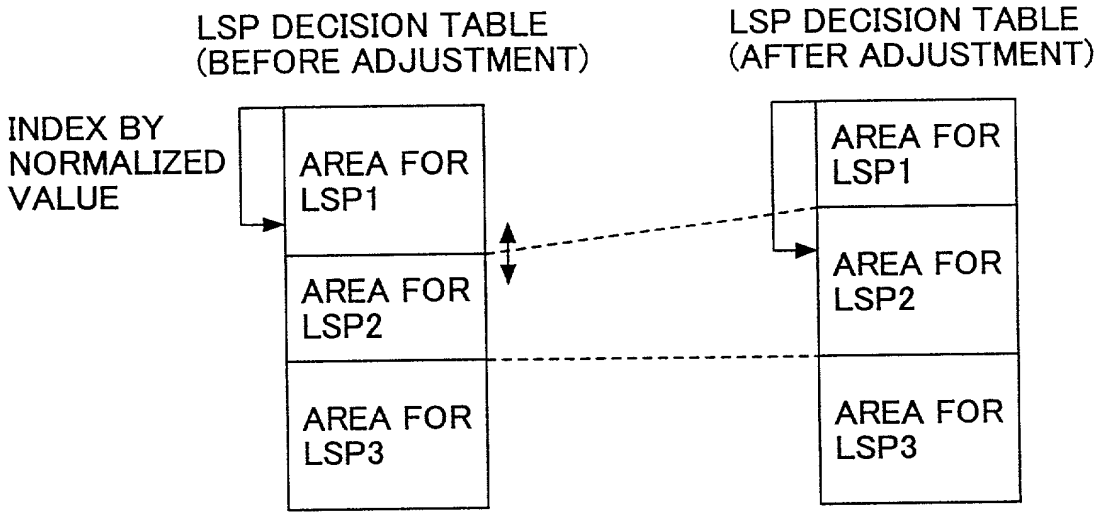

CORE NODE
CORE NODE
LSP1
MOVE MICRO FLOW
LSP2
LSP3
a.a.0.0
EDGE NODE
20
21
EDGE NODE
b.b.0.0

FIG.5A

FIG.5B


LSP DECISION TABLE
(BEFORE ADJUSTMENT)
INDEX BY
NORMALIZED
VALUE
AREA FOR
LSP1
AREA FOR
LSP2
AREA FOR
LSP3
LSP DECISION TABLE
(AFTER ADJUSTMENT)
AREA FOR
LSP1
AREA FOR
LSP2
AREA FOR
LSP3

EUROPEAN SEARCH REPORT

FIG.6

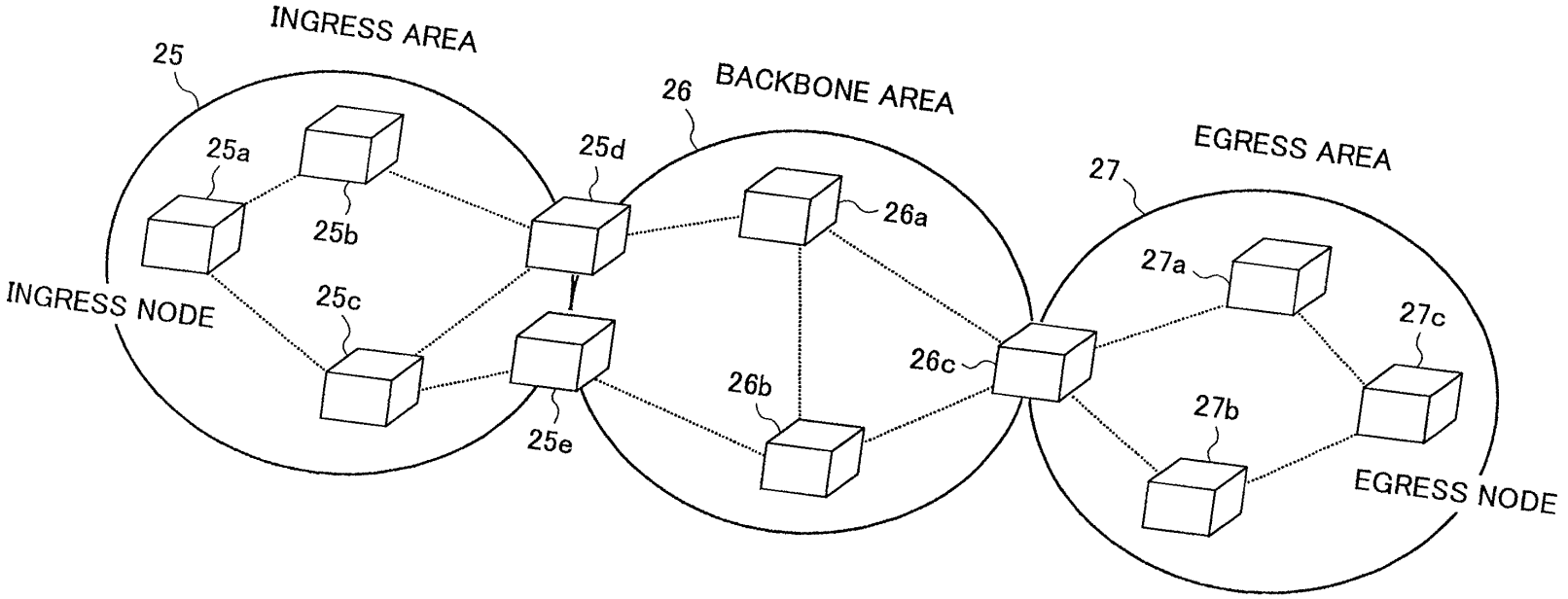


FIG.7

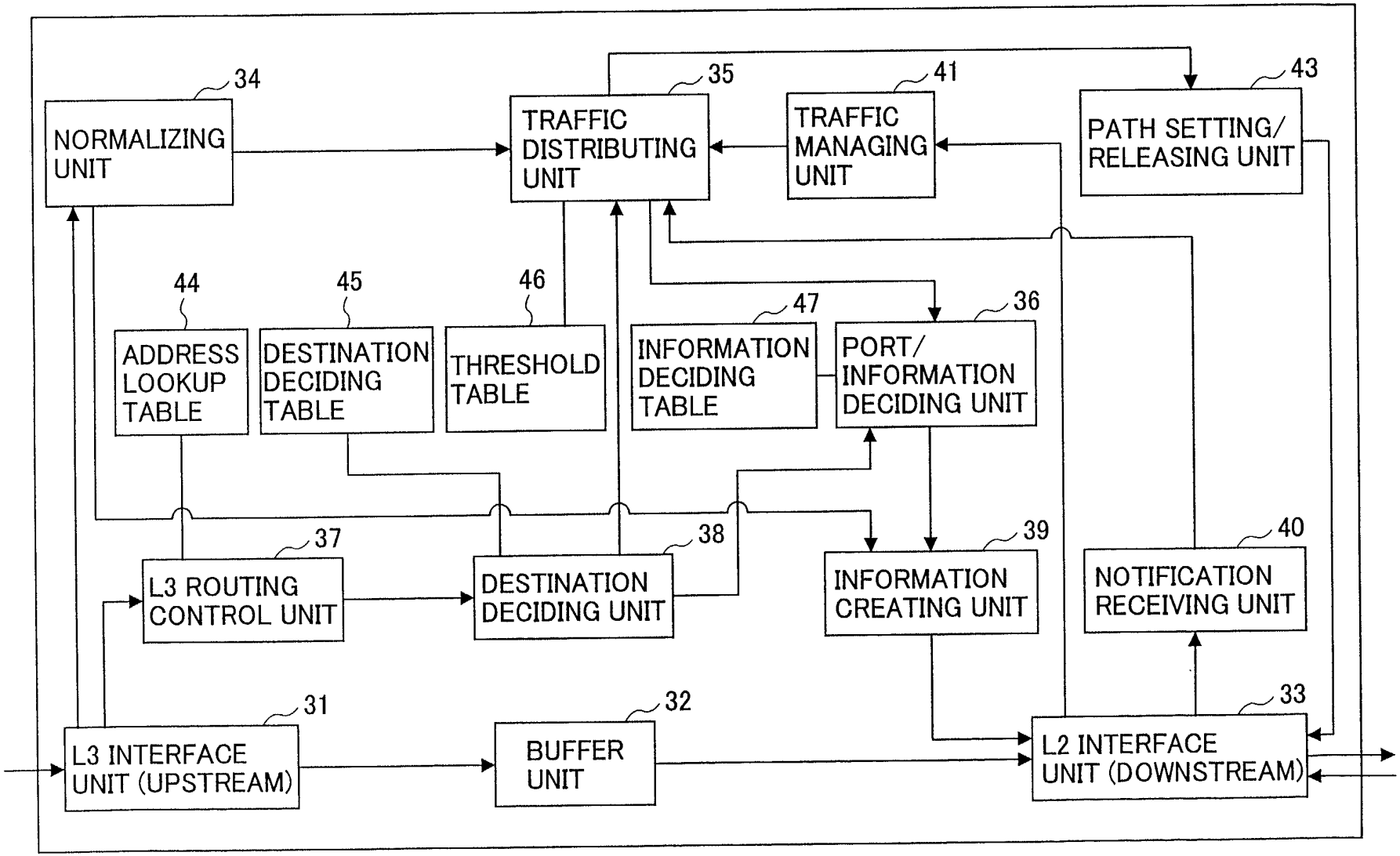

34
NORMALIZING UNIT
35
TRAFFIC DISTRIBUTING UNIT
41
TRAFFIC MANAGING UNIT
43
PATH SETTING/ RELEASING UNIT
44
ADDRESS LOOKUP TABLE
45
DESTINATION DECIDING TABLE
46
THRESHOLD TABLE
47
INFORMATION DECIDING TABLE
36
PORT/ INFORMATION DECIDING UNIT
37
L3 ROUTING CONTROL UNIT
38
DESTINATION DECIDING UNIT
39
INFORMATION CREATING UNIT
40
NOTIFICATION RECEIVING UNIT
31
L3 INTERFACE UNIT (UPSTREAM)
32
BUFFER UNIT
33
L2 INTERFACE UNIT (DOWNSTREAM)

FIG.8

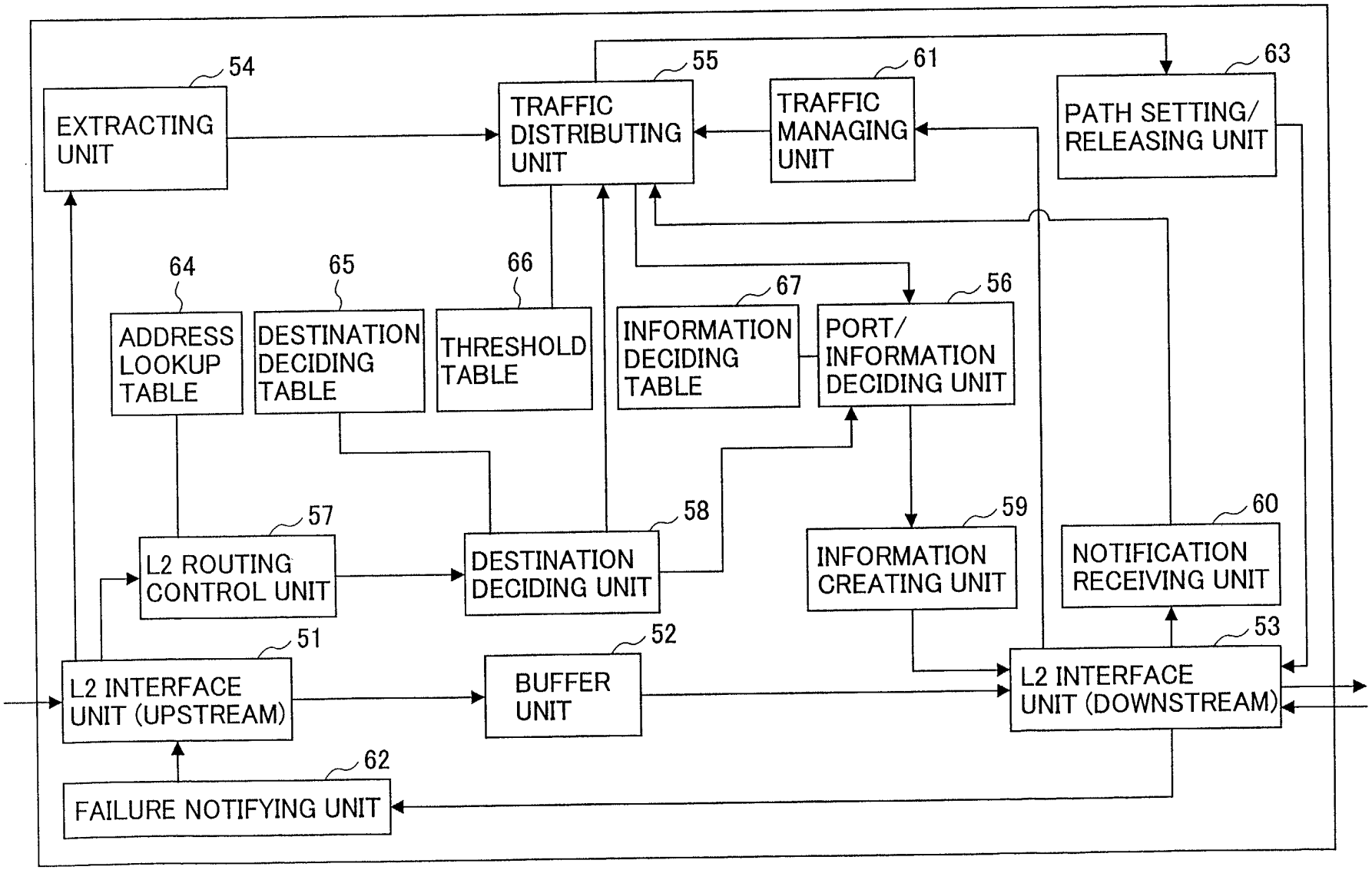
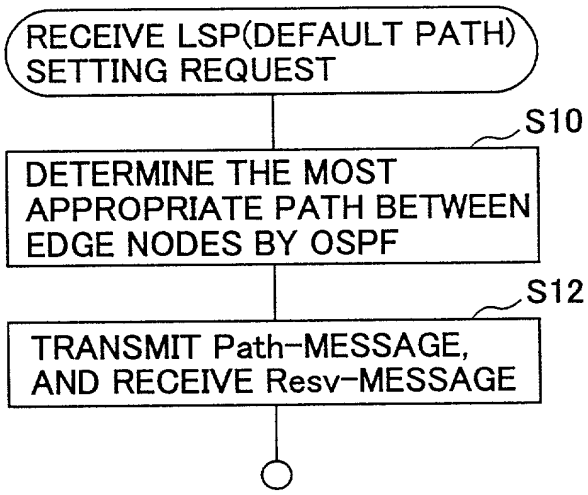

54
EXTRACTING UNIT
55
TRAFFIC DISTRIBUTING UNIT
61
TRAFFIC MANAGING UNIT
63
PATH SETTING/ RELEASING UNIT
64
ADDRESS LOOKUP TABLE
65
DESTINATION DECIDING TABLE
66
THRESHOLD TABLE
67
INFORMATION DECIDING TABLE
56
PORT/ INFORMATION DECIDING UNIT
57
L2 ROUTING CONTROL UNIT
58
DESTINATION DECIDING UNIT
59
INFORMATION CREATING UNIT
60
NOTIFICATION RECEIVING UNIT
51
L2 INTERFACE UNIT (UPSTREAM)
52
BUFFER UNIT
53
L2 INTERFACE UNIT (DOWNSTREAM)
62
FAILURE NOTIFYING UNIT

FIG.9


RECEIVE LSP(DEFAULT PATH) SETTING REQUEST
S10
DETERMINE THE MOST APPROPRIATE PATH BETWEEN EDGE NODES BY OSPF
S12
TRANSMIT Path-MESSAGE, AND RECEIVE Resv-MESSAGE

FUJITSU-STES8860

FIG.10

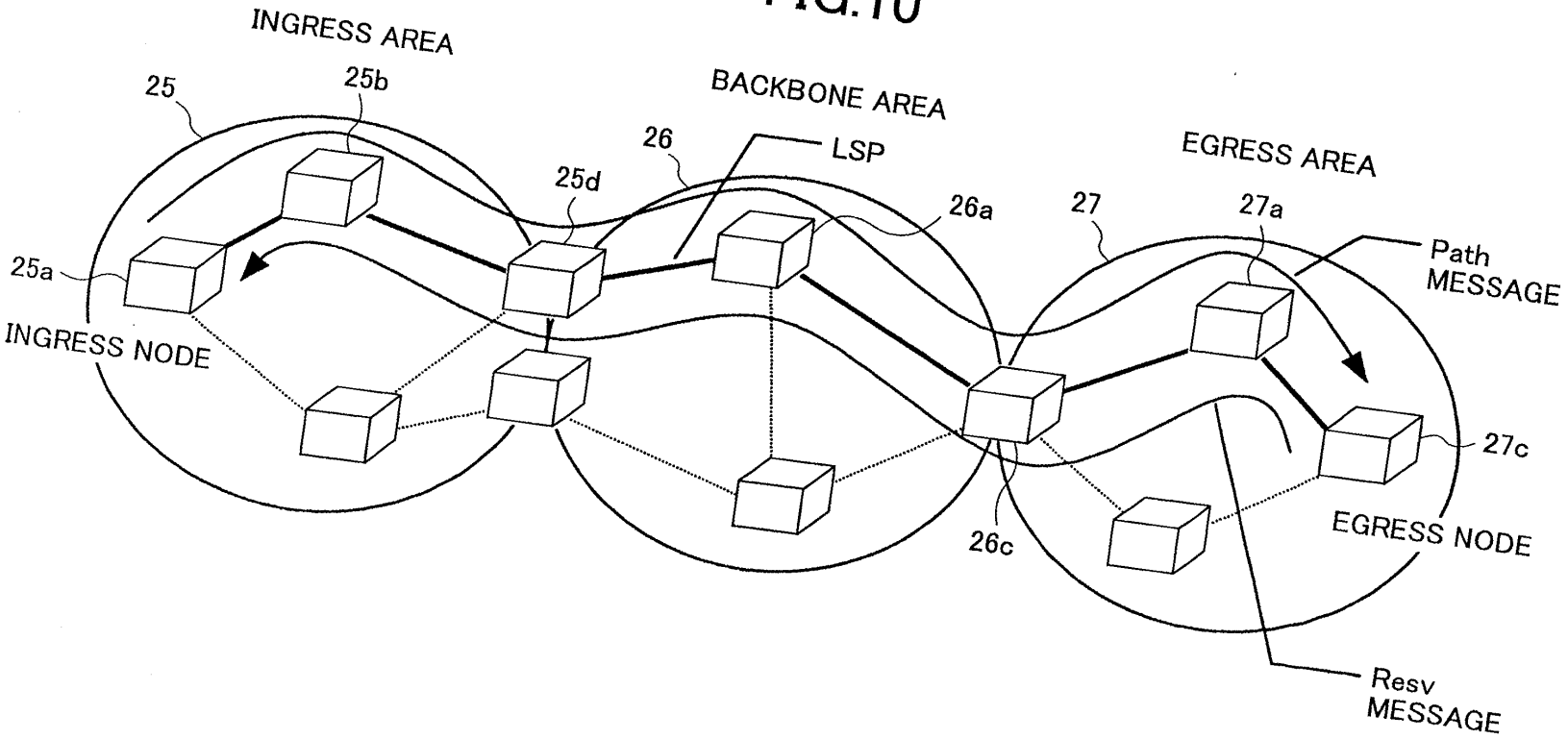


FIG.11

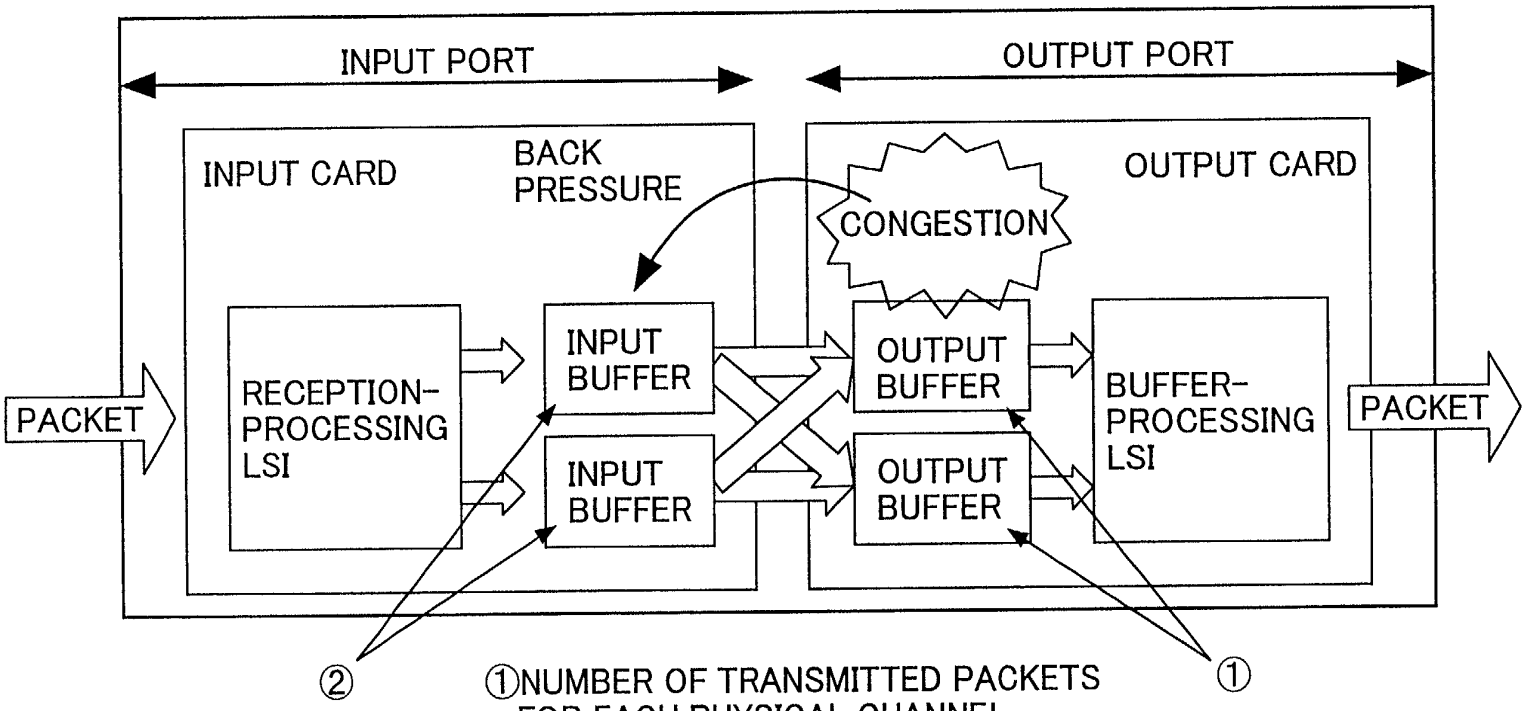

INPUT PORT
OUTPUT PORT
INPUT CARD
BACK PRESSURE
CONGESTION
OUTPUT CARD
PACKET
RECEPTION-PROCESSING LSI
INPUT BUFFER
INPUT BUFFER
OUTPUT BUFFER
OUTPUT BUFFER
BUFFER-PROCESSING LSI
PACKET
②
①
①NUMBER OF TRANSMITTED PACKETS FOR EACH PHYSICAL CHANNEL
②NUMBER OF DISCARDED PACKETS FOR EACH PHYSICAL CHANNEL

FIG.12

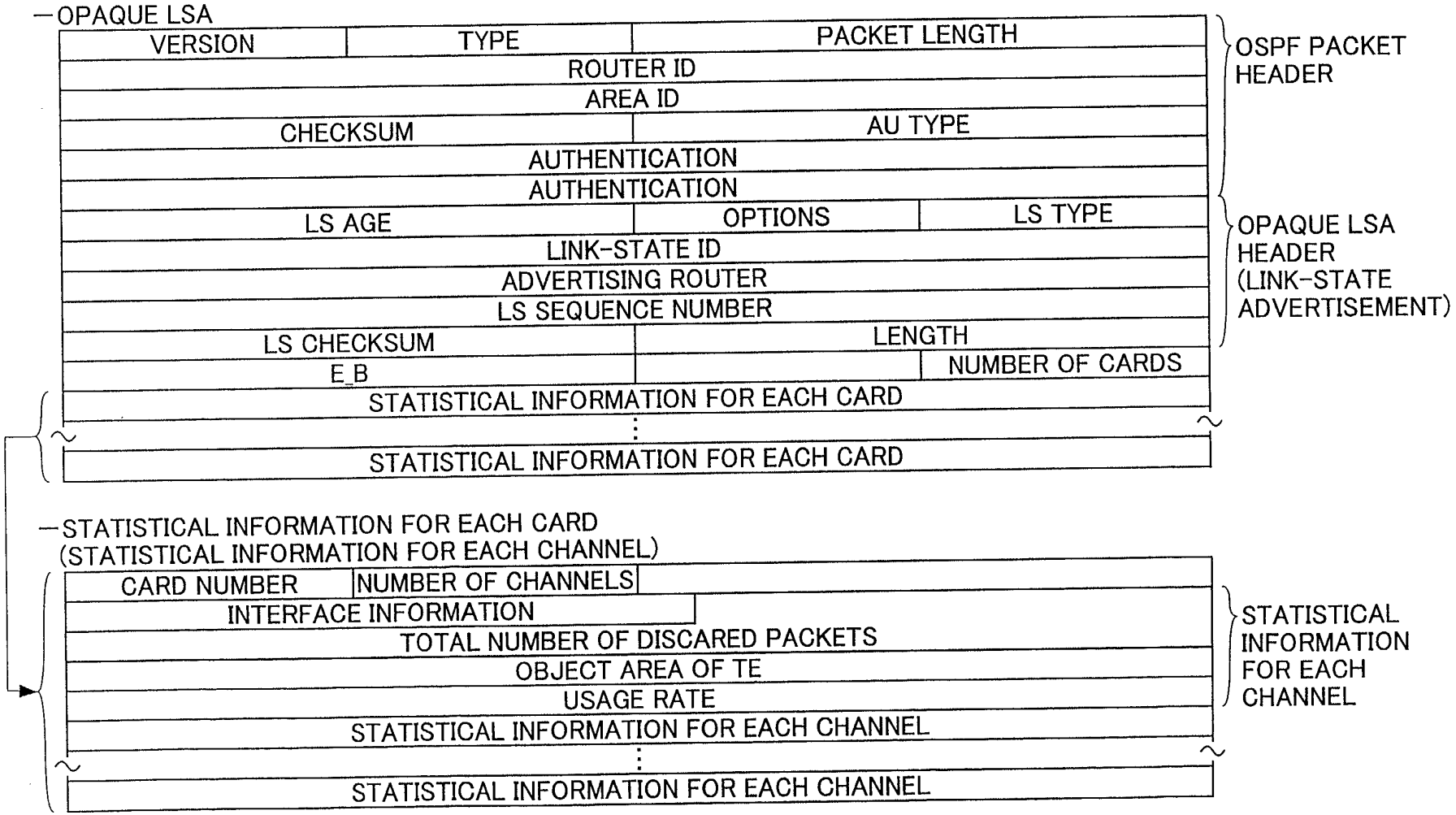

OPAQUE LSA
VERSION
TYPE
PACKET LENGTH
ROUTER ID
AREA ID
CHECKSUM
AU TYPE
AUTHENTICATION
AUTHENTICATION
LS AGE
OPTIONS
LS TYPE
LINK-STATE ID
ADVERTISING ROUTER
LS SEQUENCE NUMBER
LS CHECKSUM
LENGTH
E_B
NUMBER OF CARDS
STATISTICAL INFORMATION FOR EACH CARD
STATISTICAL INFORMATION FOR EACH CARD
OSPF PACKET HEADER
OPAQUE LSA HEADER (LINK-STATE ADVERTISEMENT)
STATISTICAL INFORMATION FOR EACH CARD (STATISTICAL INFORMATION FOR EACH CHANNEL)
CARD NUMBER
NUMBER OF CHANNELS
INTERFACE INFORMATION
TOTAL NUMBER OF DISCARED PACKETS
OBJECT AREA OF TE
USAGE RATE
STATISTICAL INFORMATION FOR EACH CHANNEL
STATISTICAL INFORMATION FOR EACH CHANNEL
STATISTICAL INFORMATION FOR EACH CHANNEL

FIG.13

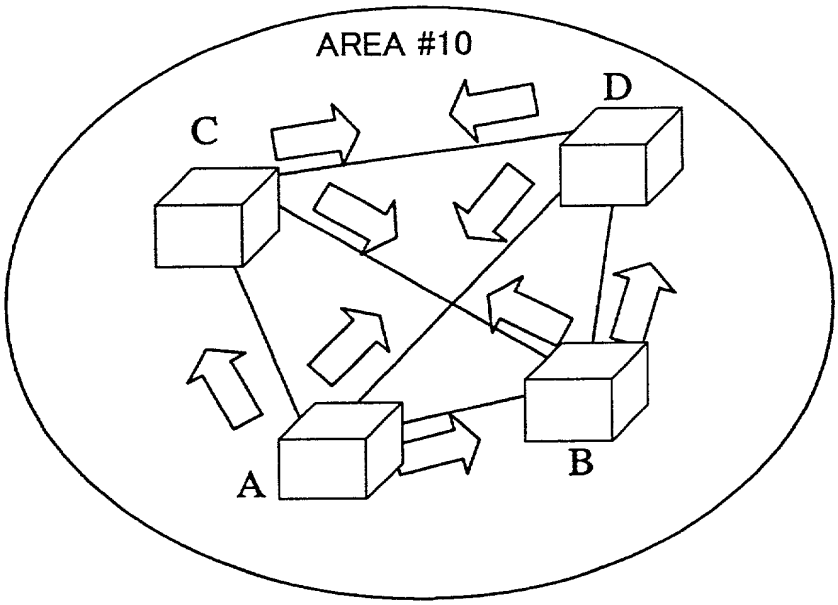


FIG.14

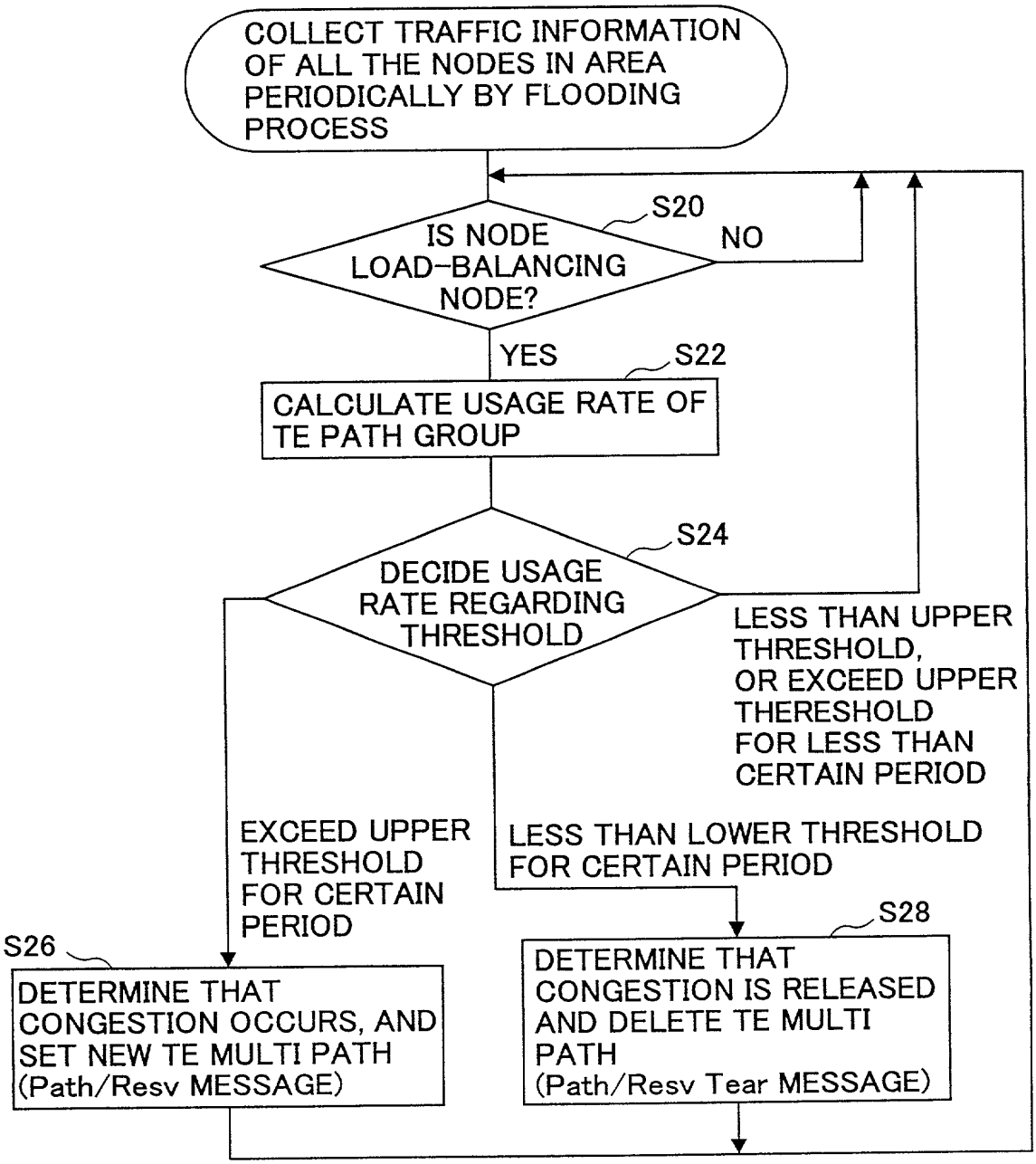

COLLECT TRAFFIC INFORMATION OF ALL THE NODES IN AREA PERIODICALLY BY FLOODING PROCESS
S20
IS NODE LOAD-BALANCING NODE?
NO
YES
S22
CALCULATE USAGE RATE OF TE PATH GROUP
S24
DECIDE USAGE RATE REGARDING THRESHOLD
LESS THAN UPPER THRESHOLD, OR EXCEED UPPER THERESHOLD FOR LESS THAN CERTAIN PERIOD
EXCEED UPPER THRESHOLD FOR CERTAIN PERIOD
LESS THAN LOWER THRESHOLD FOR CERTAIN PERIOD
S26
DETERMINE THAT CONGESTION OCCURS, AND SET NEW TE MULTI PATH (Path/Resv MESSAGE)
S28
DETERMINE THAT CONGESTION IS RELEASED AND DELETE TE MULTI PATH (Path/Resv Tear MESSAGE)

FIG.15

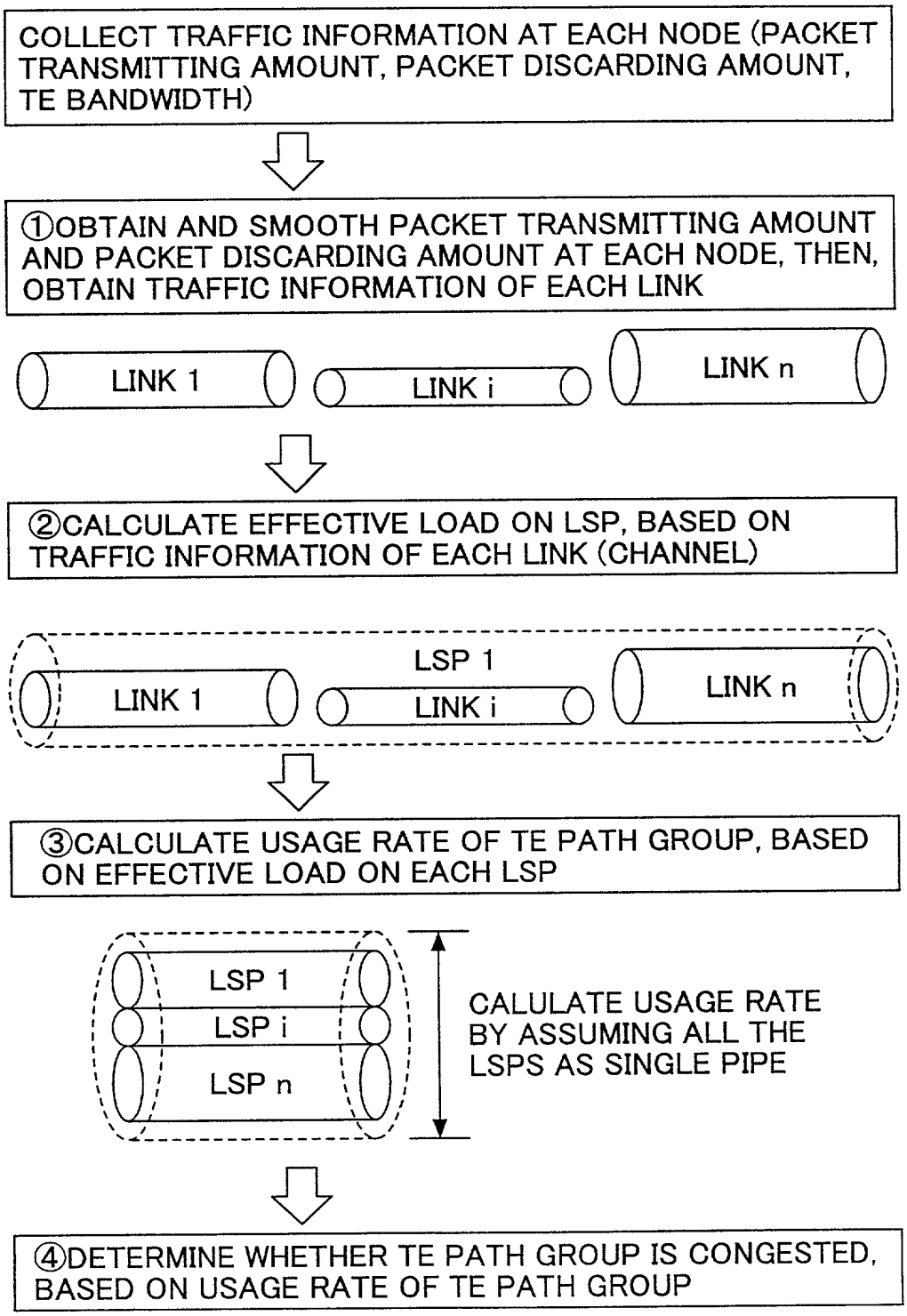

COLLECT TRAFFIC INFORMATION AT EACH NODE (PACKET TRANSMITTING AMOUNT, PACKET DISCARDING AMOUNT, TE BANDWIDTH)
①OBTAIN AND SMOOTH PACKET TRANSMITTING AMOUNT AND PACKET DISCARDING AMOUNT AT EACH NODE, THEN, OBTAIN TRAFFIC INFORMATION OF EACH LINK
LINK 1
LINK i
LINK n
②CALCULATE EFFECTIVE LOAD ON LSP, BASED ON TRAFFIC INFORMATION OF EACH LINK (CHANNEL)
LSP 1
LINK 1
LINK i
LINK n
③CALCULATE USAGE RATE OF TE PATH GROUP, BASED ON EFFECTIVE LOAD ON EACH LSP
LSP 1
LSP i
LSP n
CALULATE USAGE RATE BY ASSUMING ALL THE LSPS AS SINGLE PIPE
④DETERMINE WHETHER TE PATH GROUP IS CONGESTED, BASED ON USAGE RATE OF TE PATH GROUP

FIG.16

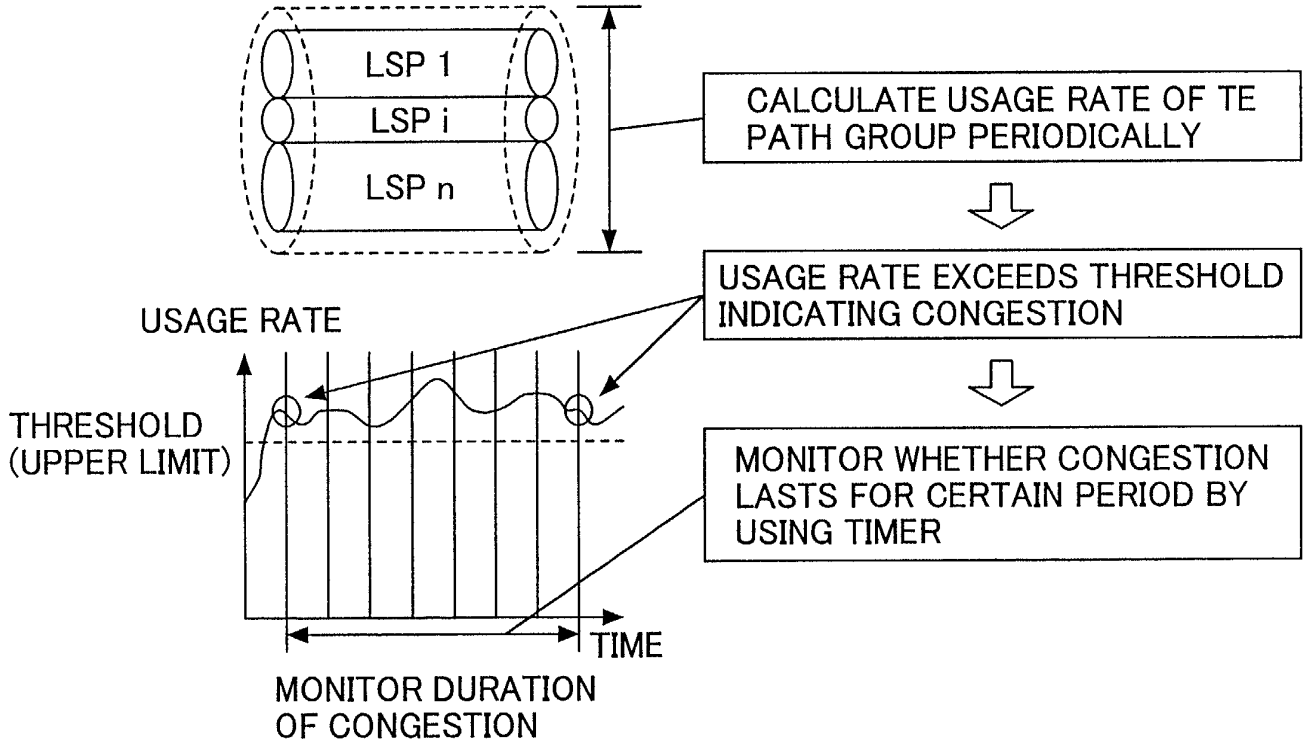

LSP 1
LSP i
LSP n
CALCULATE USAGE RATE OF TE PATH GROUP PERIODICALLY
USAGE RATE EXCEEDS THRESHOLD INDICATING CONGESTION
MONITOR WHETHER CONGESTION LASTS FOR CERTAIN PERIOD BY USING TIMER
USAGE RATE
THRESHOLD (UPPER LIMIT)
TIME
MONITOR DURATION OF CONGESTION

FIG.17

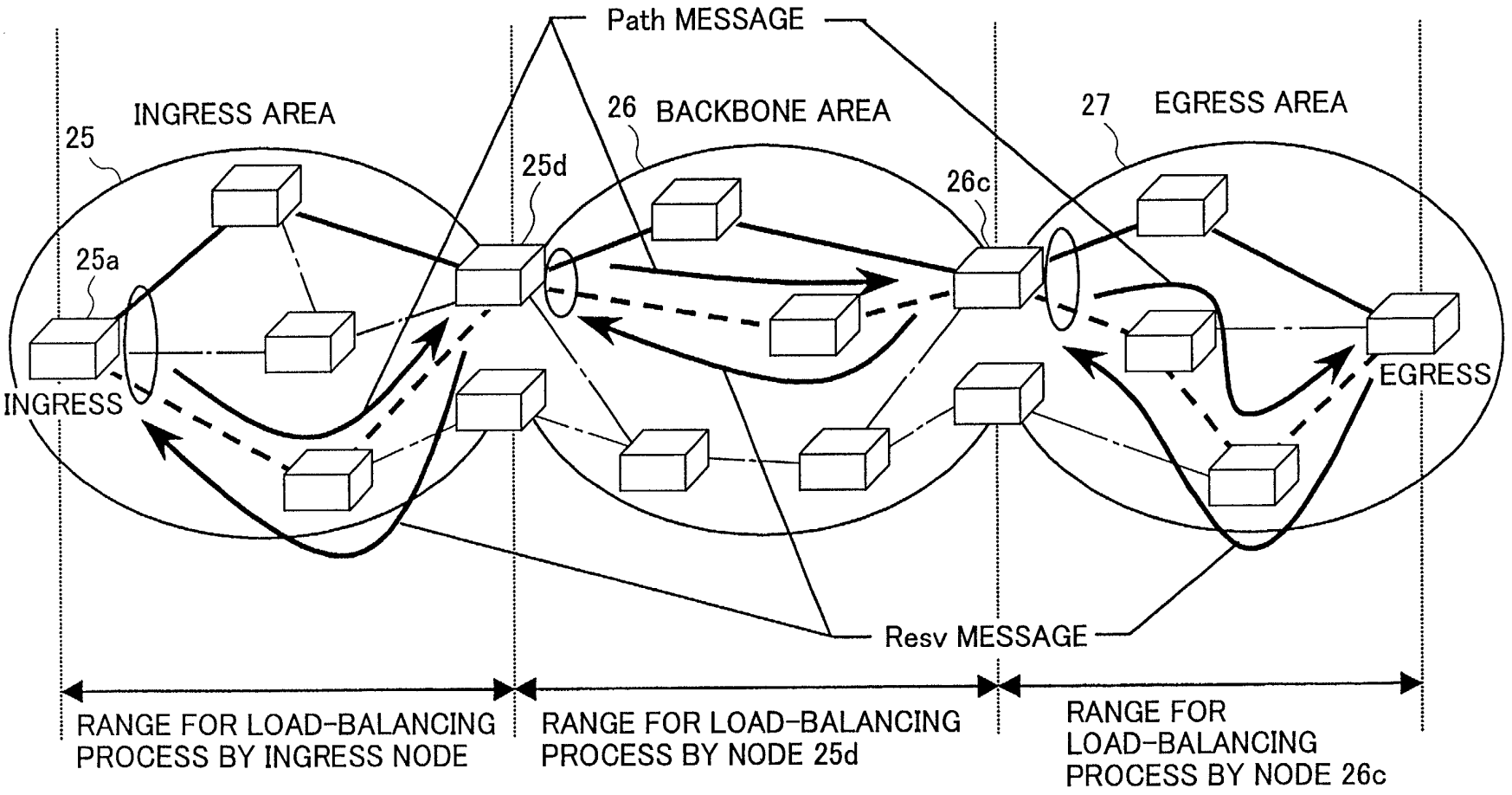

Path MESSAGE
INGRESS AREA
25
26 BACKBONE AREA
27 EGRESS AREA
25d
26c
25a
INGRESS
EGRESS
Resv MESSAGE
RANGE FOR LOAD-BALANCING PROCESS BY INGRESS NODE
RANGE FOR LOAD-BALANCING PROCESS BY NODE 25d
RANGE FOR LOAD-BALANCING PROCESS BY NODE 26c

FIG.18

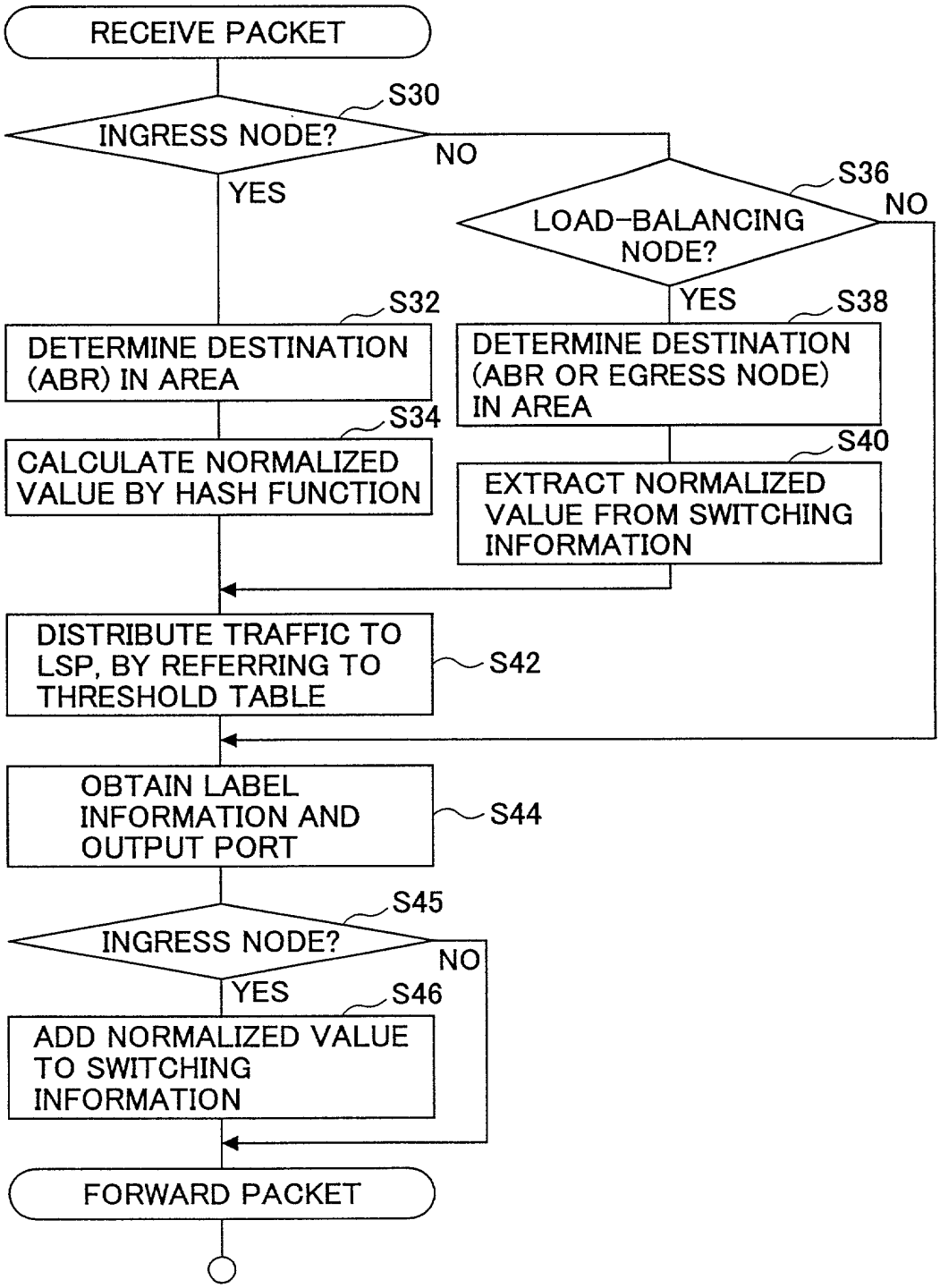

RECEIVE PACKET
S30
INGRESS NODE?
NO
YES
S36
LOAD-BALANCING NODE?
NO
YES
S32
DETERMINE DESTINATION (ABR) IN AREA
S38
DETERMINE DESTINATION (ABR OR EGRESS NODE) IN AREA
S34
CALCULATE NORMALIZED VALUE BY HASH FUNCTION
S40
EXTRACT NORMALIZED VALUE FROM SWITCHING INFORMATION
DISTRIBUTE TRAFFIC TO LSP, BY REFERRING TO THRESHOLD TABLE
S42
OBTAIN LABEL INFORMATION AND OUTPUT PORT
S44
S45
INGRESS NODE?
NO
YES
S46
ADD NORMALIZED VALUE TO SWITCHING INFORMATION
FORWARD PACKET

FIG.19

IP SOURCE ADDRESS	IP DESTINATION ADDRESS	ASSOCIATE POINTER

FIG.20

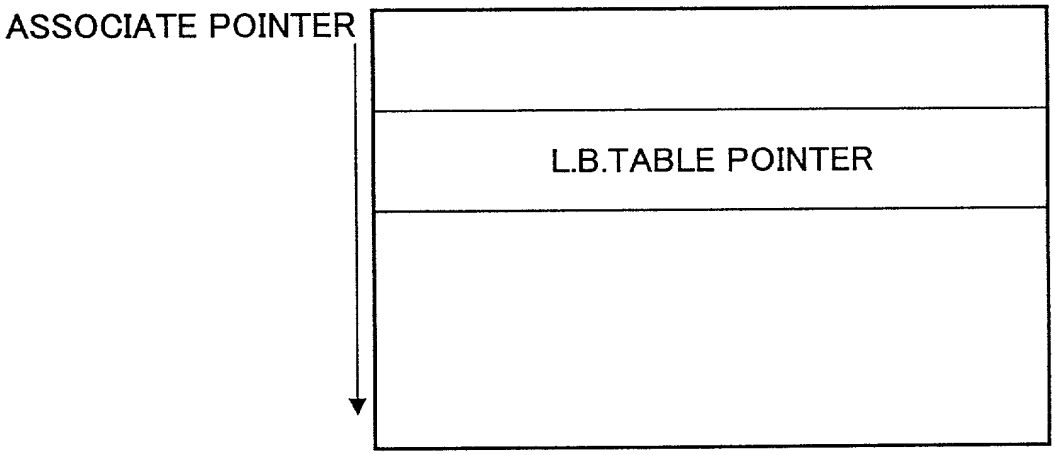


FIG.21

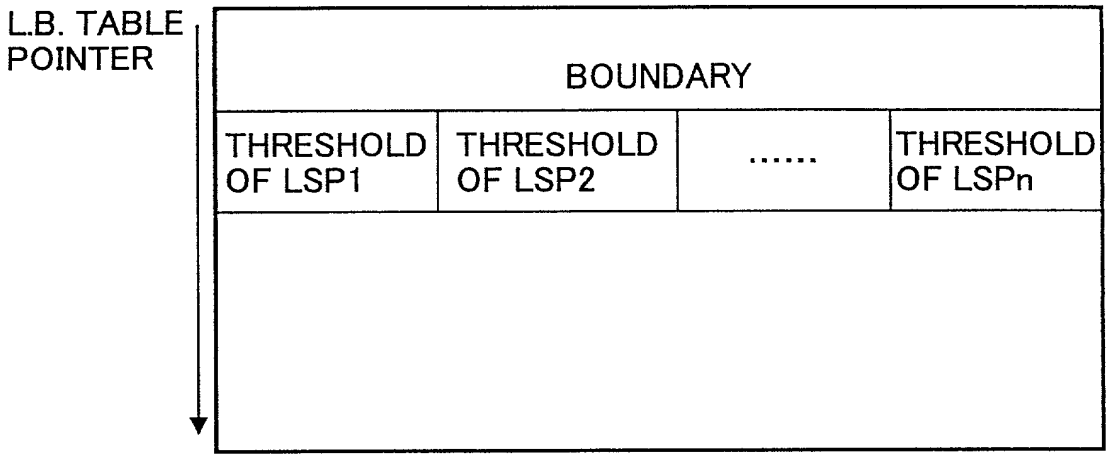

L.B. TABLE POINTER
BOUNDARY
THRESHOLD OF LSP1
THRESHOLD OF LSP2
.....
THRESHOLD OF LSPn

FIG.22

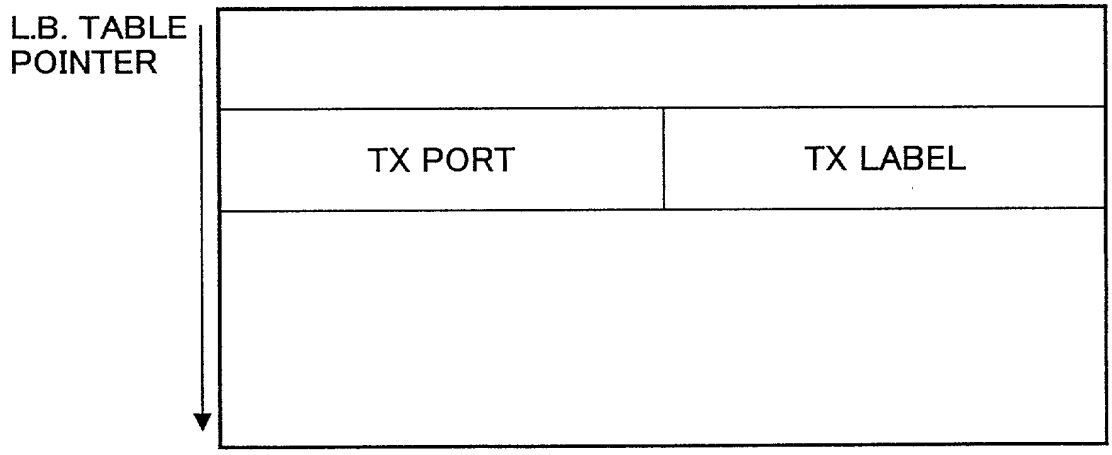

L.B. TABLE POINTER
TX PORT
TX LABEL

FIG.23A

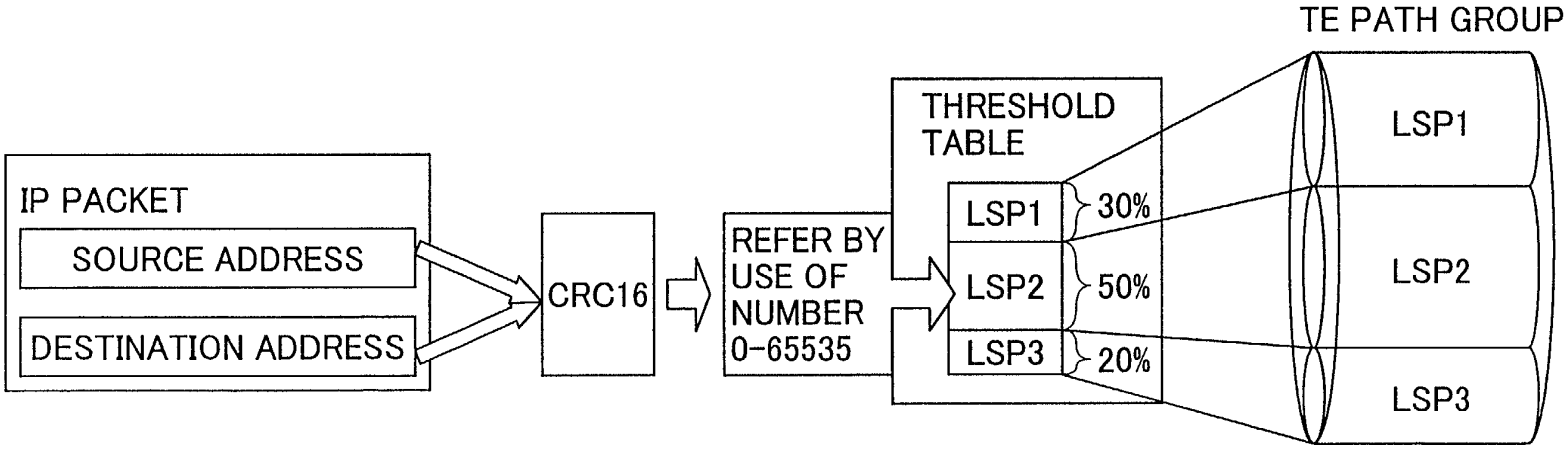

TE PATH GROUP
IP PACKET
SOURCE ADDRESS
DESTINATION ADDRESS
CRC16
REFER BY USE OF NUMBER 0-65535
THRESHOLD TABLE
LSP1
30%
LSP2
50%
LSP3
20%
LSP1
LSP2
LSP3

FIG.23B

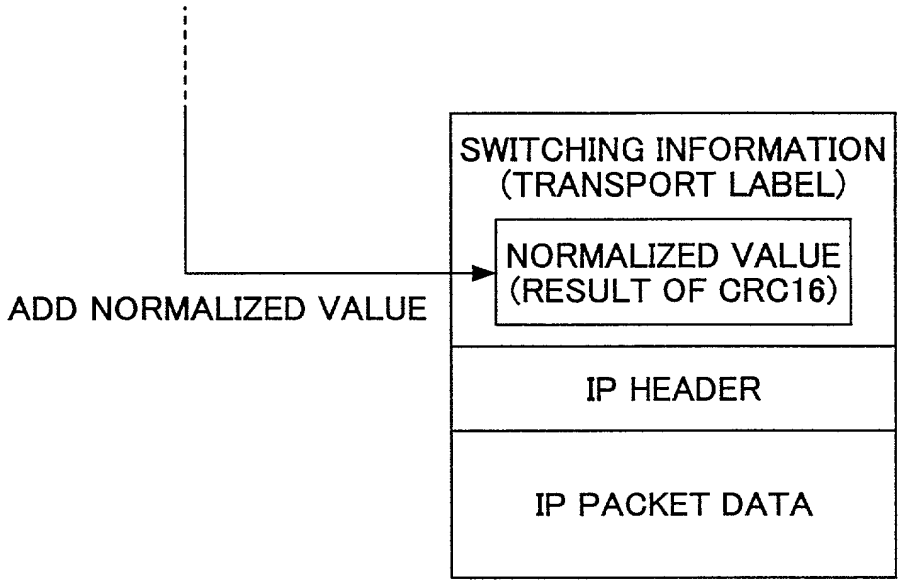

SWITCHING INFORMATION
(TRANSPORT LABEL)
NORMALIZED VALUE
(RESULT OF CRC16)
ADD NORMALIZED VALUE
IP HEADER
IP PACKET DATA

FIG.23C

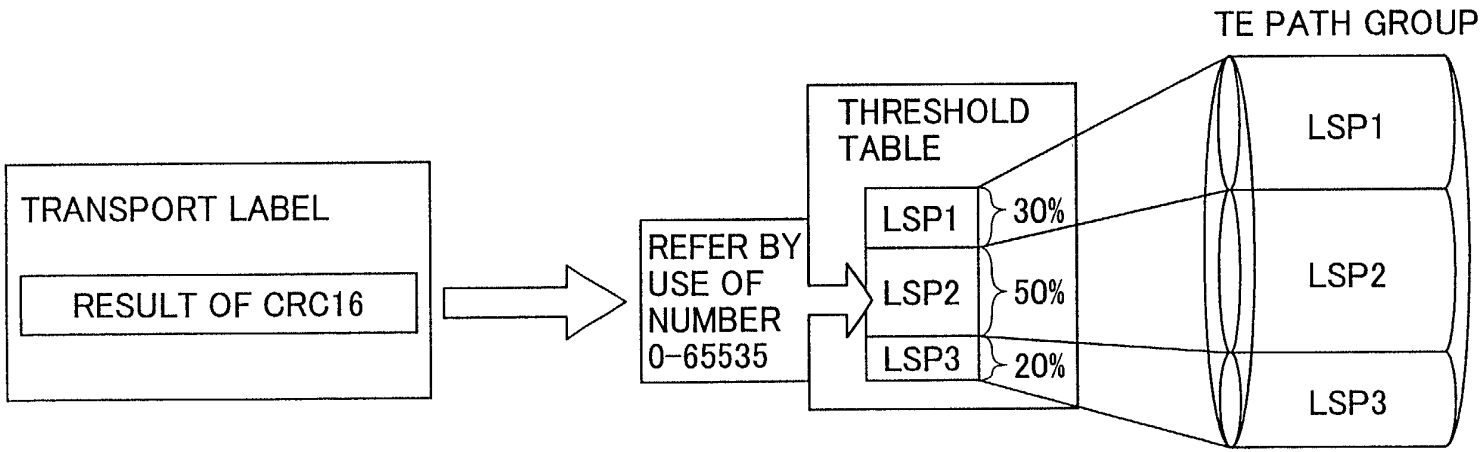

TE PATH GROUP
TRANSPORT LABEL
RESULT OF CRC16
REFER BY USE OF NUMBER 0-65535
THRESHOLD TABLE
LSP1
30%
LSP2
50%
LSP3
20%
LSP1
LSP2
LSP3

FIG.24

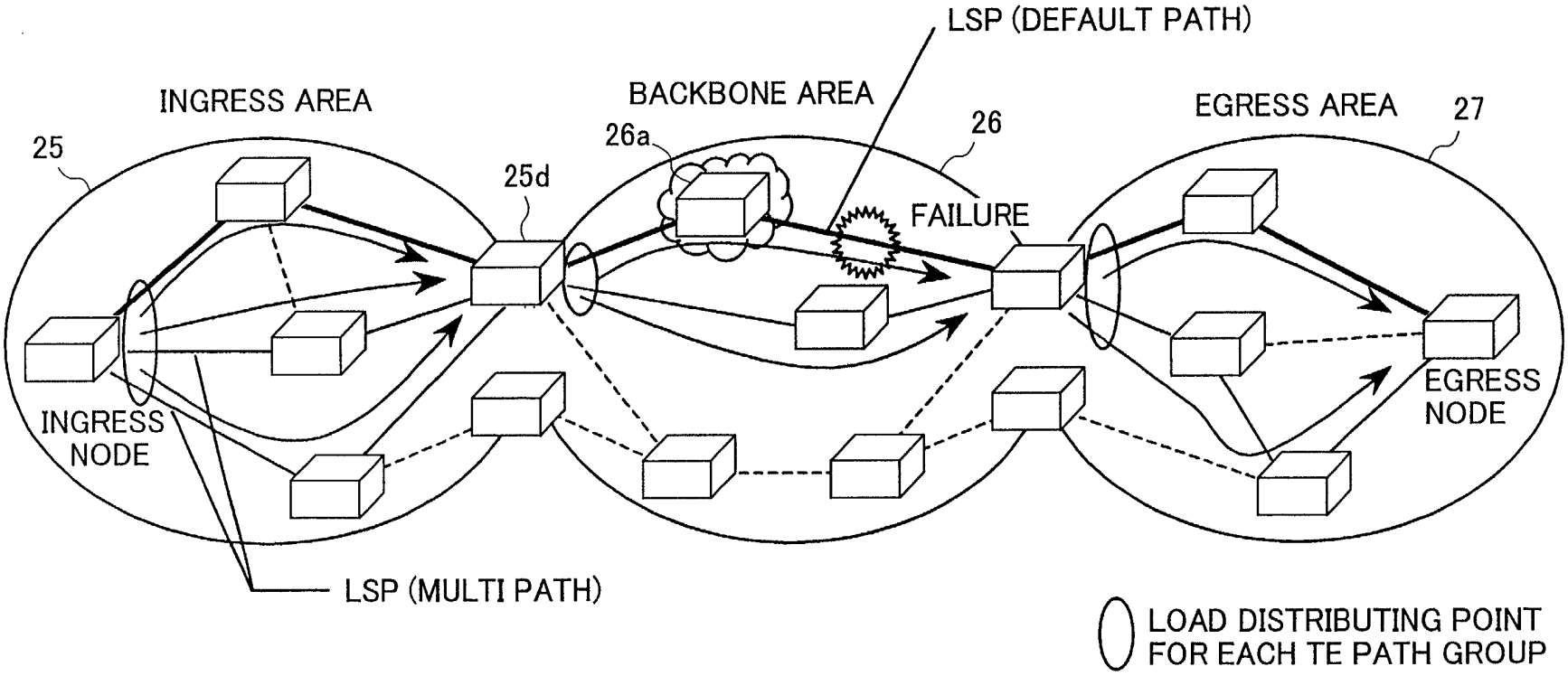

LSP (DEFAULT PATH)
INGRESS AREA
BACKBONE AREA
EGRESS AREA
25
26a
26
27
25d
FAILURE
INGRESS NODE
EGRESS NODE
LSP (MULTI PATH)
LOAD DISTRIBUTING POINT FOR EACH TE PATH GROUP

FIG.25

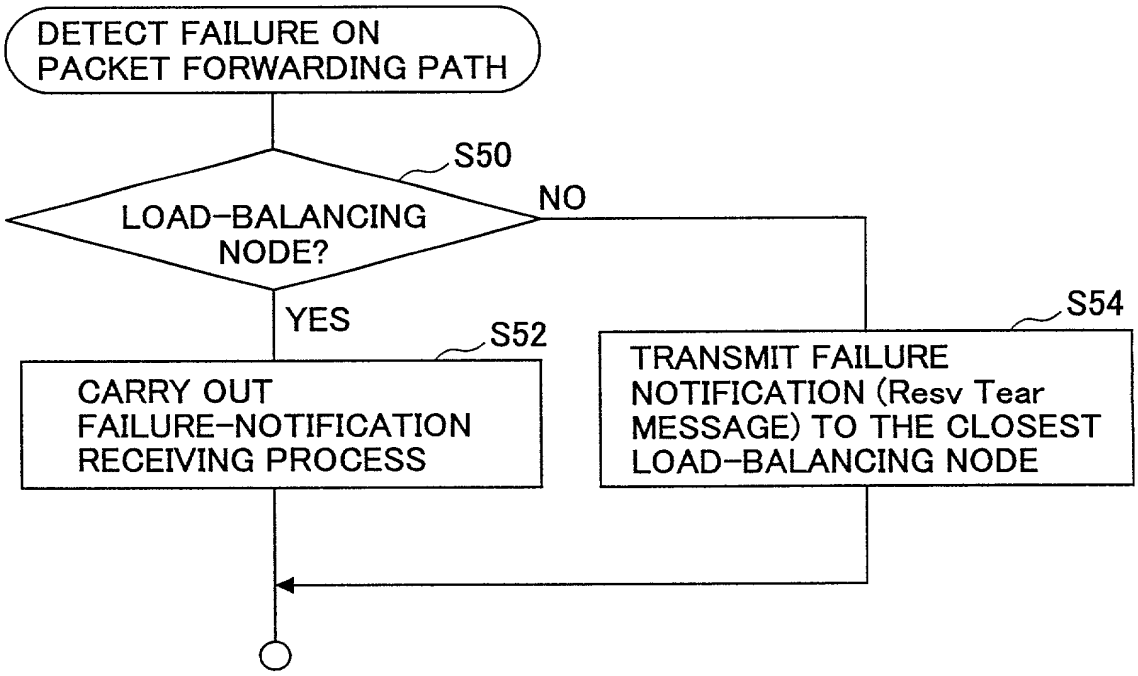

DETECT FAILURE ON PACKET FORWARDING PATH
S50
LOAD-BALANCING NODE?
NO
YES
S52
CARRY OUT FAILURE-NOTIFICATION RECEIVING PROCESS
S54
TRANSMIT FAILURE NOTIFICATION (Resv Tear MESSAGE) TO THE CLOSEST LOAD-BALANCING NODE

FIG.26

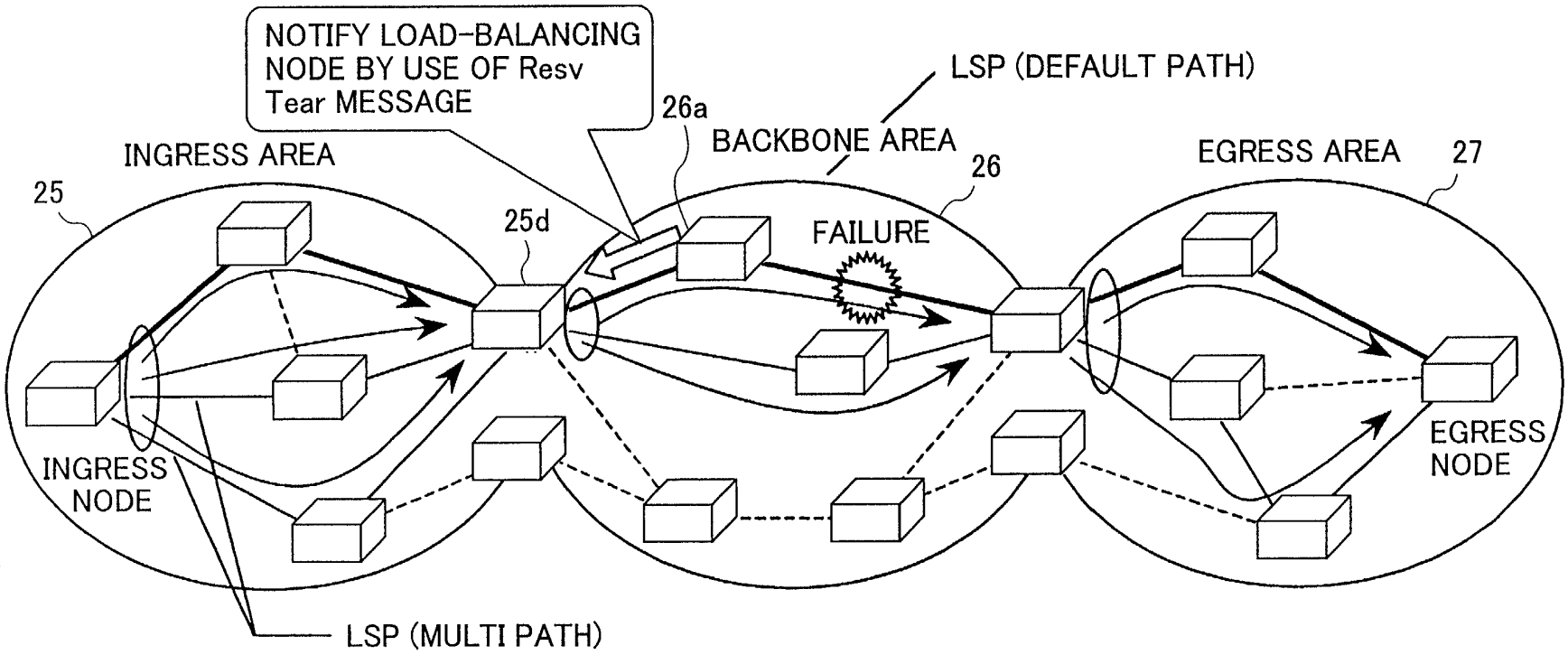

NOTIFY LOAD-BALANCING NODE BY USE OF Resv Tear MESSAGE
LSP (DEFAULT PATH)
26a
BACKBONE AREA
INGRESS AREA
EGRESS AREA
27
25
26
25d
FAILURE
INGRESS NODE
EGRESS NODE
LSP (MULTI PATH)

FIG.27

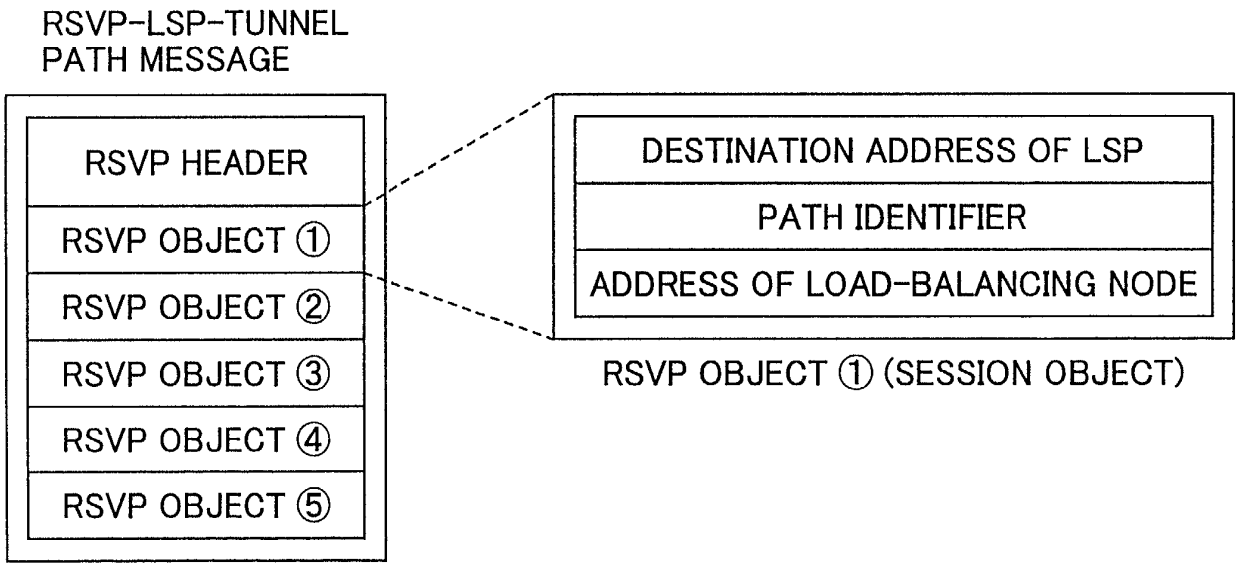

RSVP-LSP-TUNNEL
PATH MESSAGE
RSVP HEADER
RSVP OBJECT ①
RSVP OBJECT ②
RSVP OBJECT ③
RSVP OBJECT ④
RSVP OBJECT ⑤
DESTINATION ADDRESS OF LSP
PATH IDENTIFIER
ADDRESS OF LOAD-BALANCING NODE
RSVP OBJECT ① (SESSION OBJECT)

FIG.28

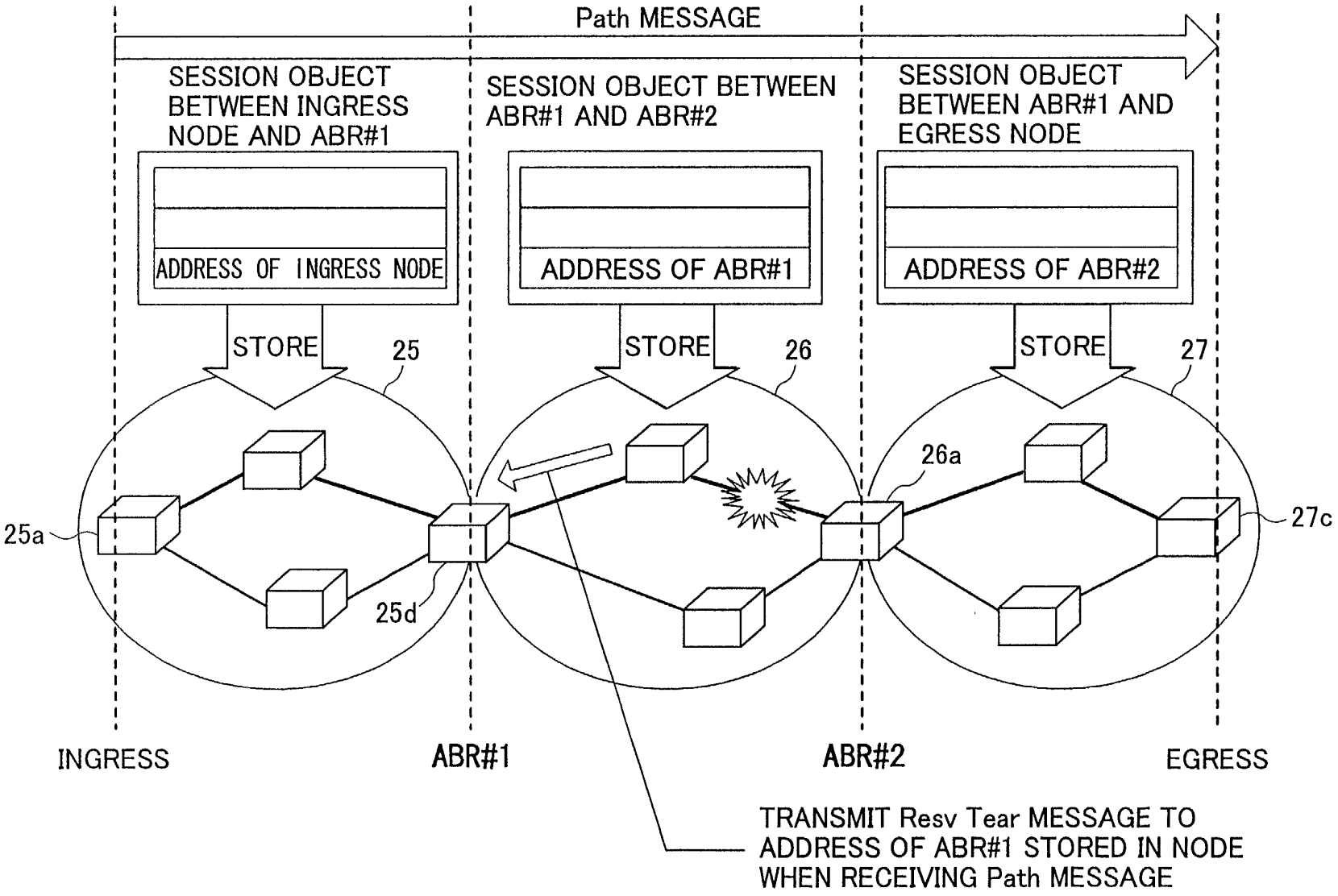

Path MESSAGE
SESSION OBJECT BETWEEN INGRESS NODE AND ABR#1
SESSION OBJECT BETWEEN ABR#1 AND ABR#2
SESSION OBJECT BETWEEN ABR#1 AND EGRESS NODE
ADDRESS OF INGRESS NODE
ADDRESS OF ABR#1
ADDRESS OF ABR#2
STORE
STORE
STORE
25
26
27
26a
25a
27c
25d
INGRESS
ABR#1
ABR#2
EGRESS
TRANSMIT Resv Tear MESSAGE TO ADDRESS OF ABR#1 STORED IN NODE WHEN RECEIVING Path MESSAGE

FIG.29

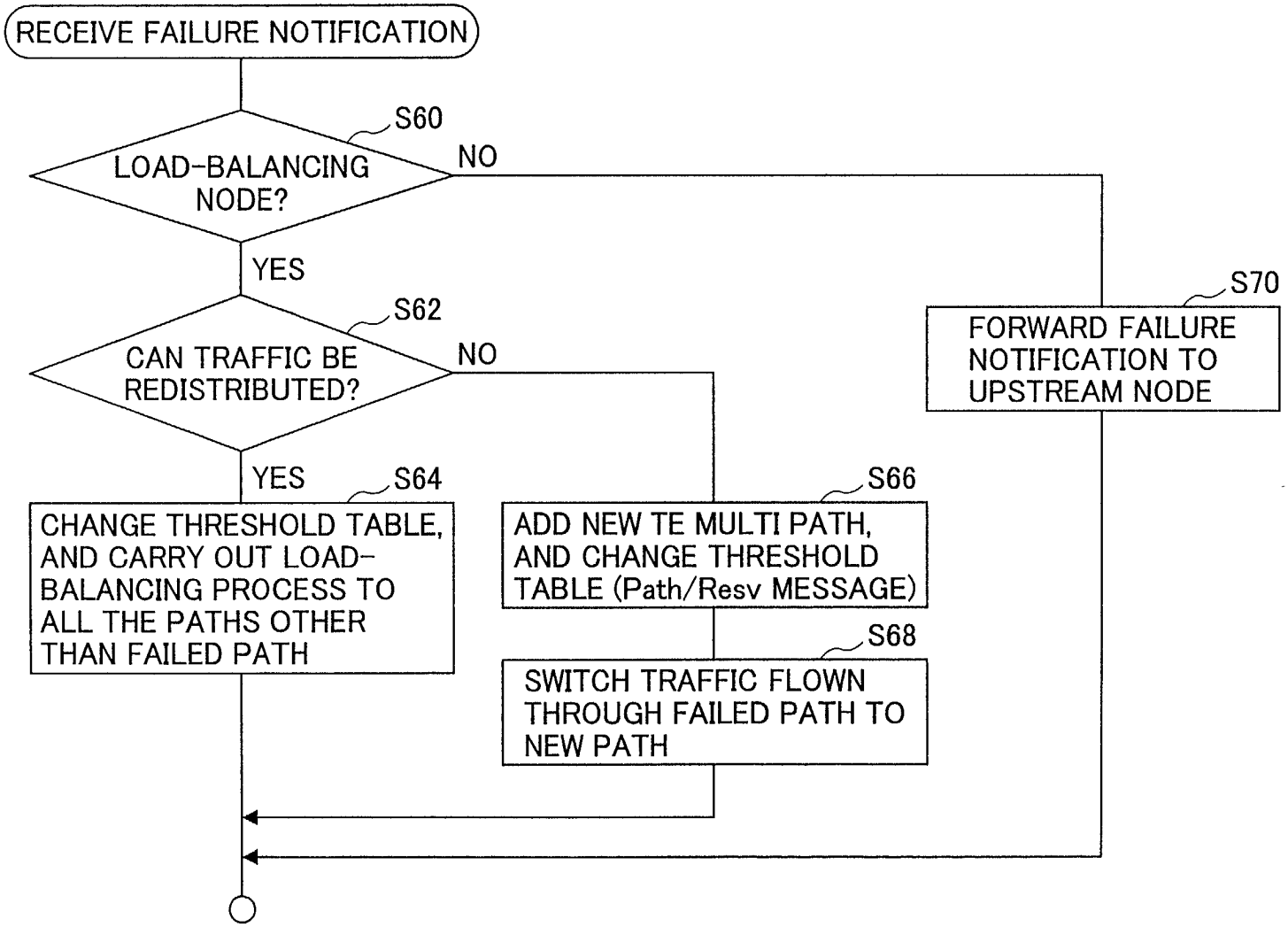
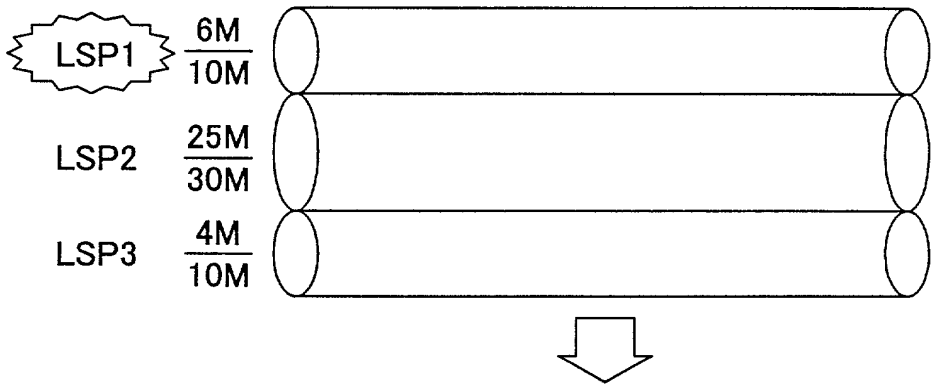
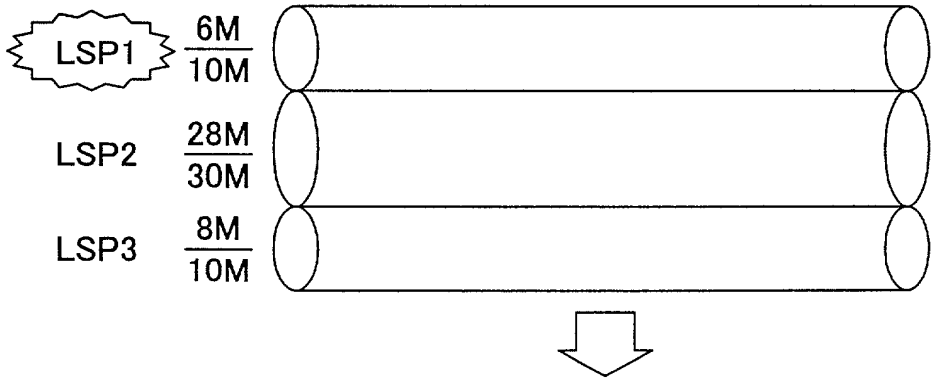

RECEIVE FAILURE NOTIFICATION
S60
LOAD-BALANCING NODE?
NO
YES
S62
CAN TRAFFIC BE REDISTRIBUTED?
NO
YES
S64
CHANGE THRESHOLD TABLE, AND CARRY OUT LOAD-BALANCING PROCESS TO ALL THE PATHS OTHER THAN FAILED PATH
S66
ADD NEW TE MULTI PATH, AND CHANGE THRESHOLD TABLE (Path/Resv MESSAGE)
S68
SWITCH TRAFFIC FLOWN THROUGH FAILED PATH TO NEW PATH
S70
FORWARD FAILURE NOTIFICATION TO UPSTREAM NODE

FIG.30A



TOTAL AVAILABLE BANDWIDTH − AVAILABLE BANDWIDTH OF LSP1 = 15M − 4M = 11M, WHICH IS GREATER THAN EFFECTIVE LOAD (6M) ON LSP1. TRAFFIC CAN BE REDISTRIBUTED WITHOUT LOSS.

FIG.30B



TOTAL AVAILABLE BANDWIDTH − AVAILABLE BANDWIDTH OF LSP1 = 8M − 4M = 4M, WHICH IS GREATER THAN EFFECTIVE LOAD (6M) ON LSP1. TRAFFIC CAN BE REDISTRIBUTED WITHOUT LOSS.

FIG.31A

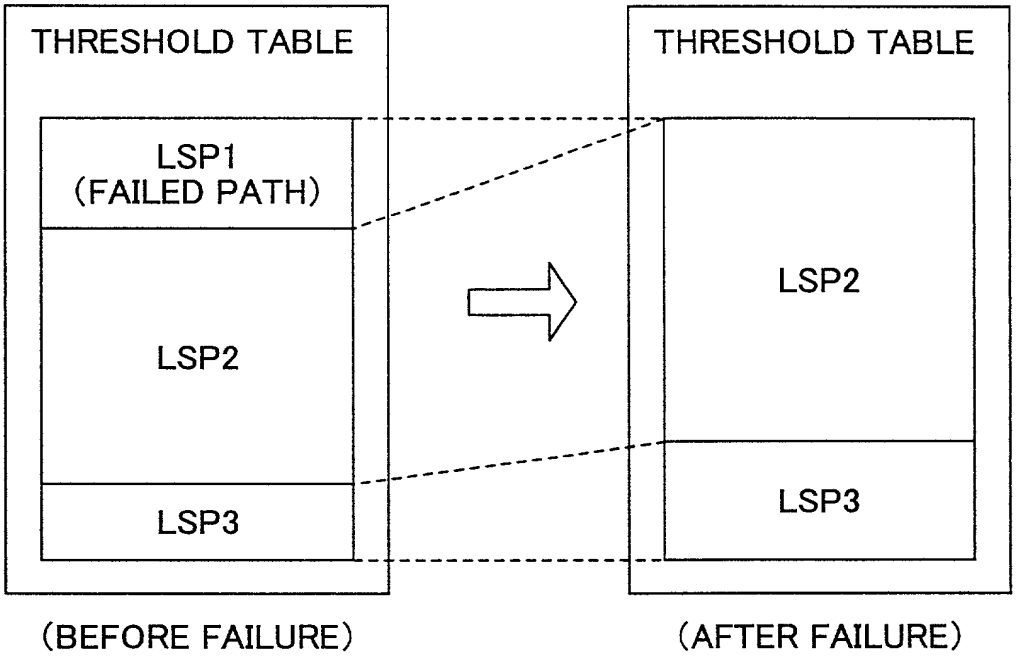


FIG.31B

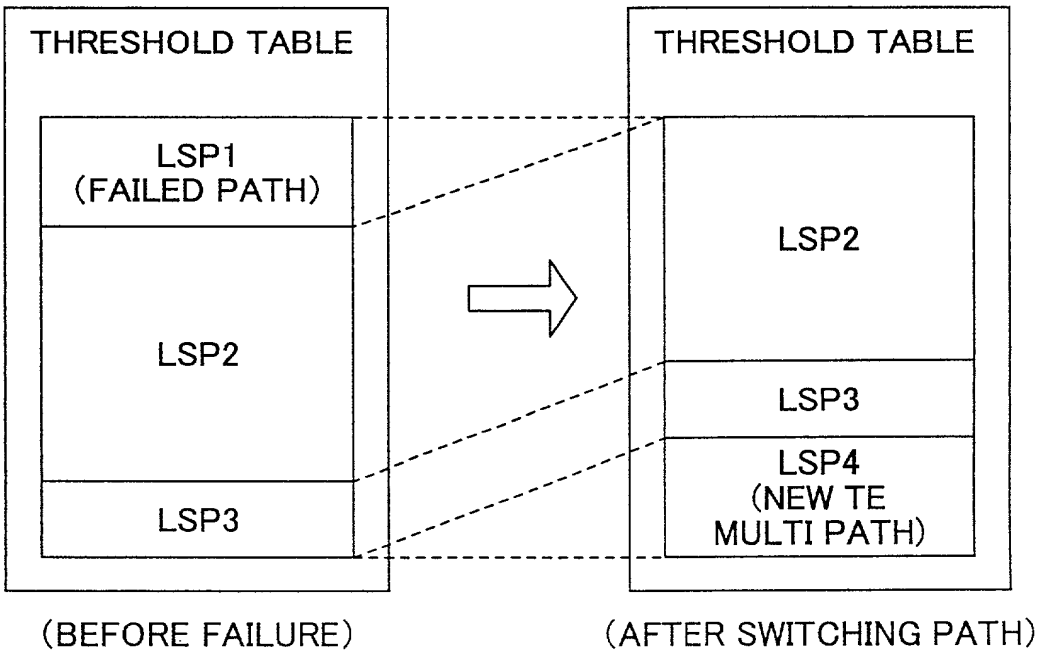


FIG.32A

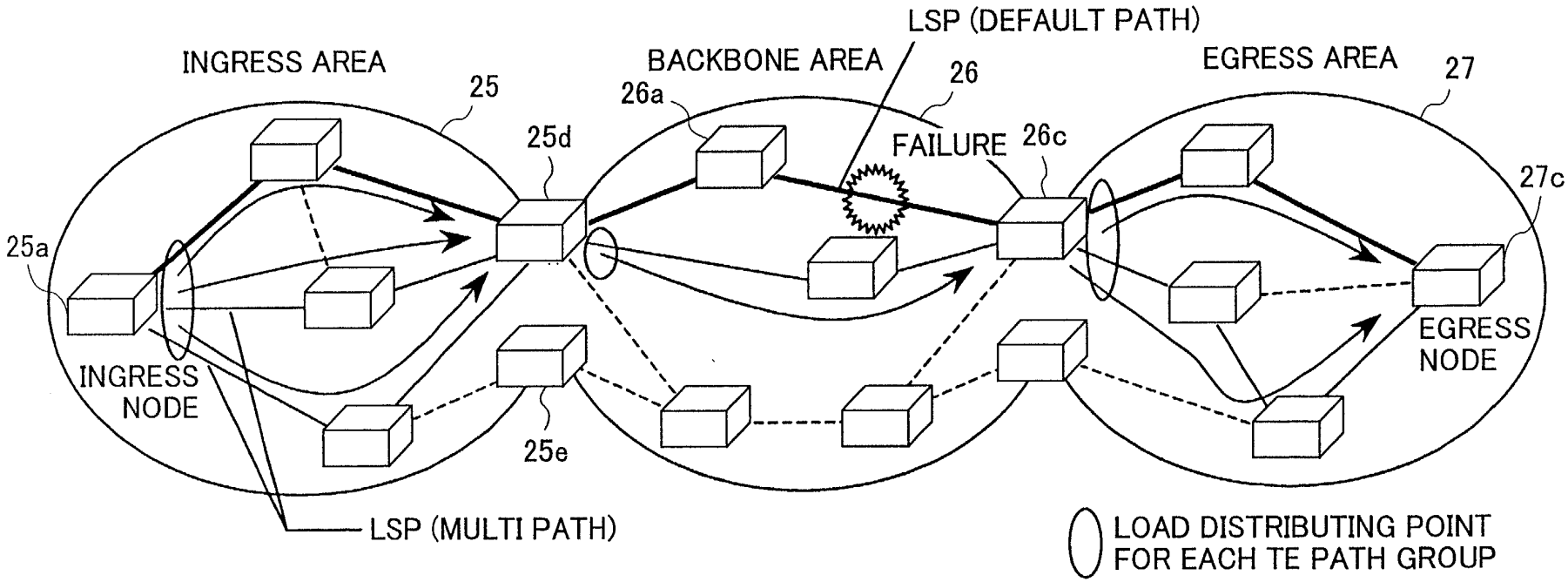
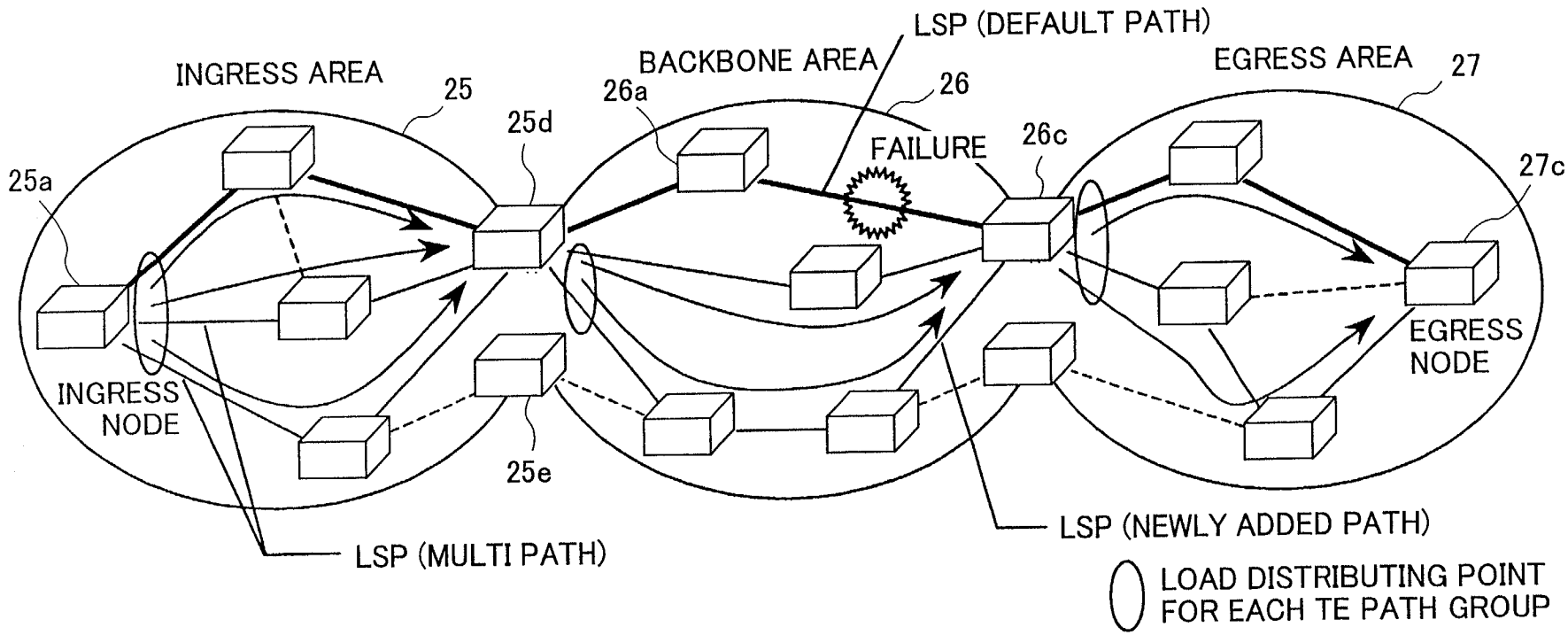

LSP (DEFAULT PATH)
INGRESS AREA
25
BACKBONE AREA
26
EGRESS AREA
27
26a
25d
FAILURE
26c
27c
25a
INGRESS NODE
EGRESS NODE
25e
LSP (MULTI PATH)
LOAD DISTRIBUTING POINT FOR EACH TE PATH GROUP

FIG.32B


LSP (DEFAULT PATH)
INGRESS AREA
25
BACKBONE AREA
26a
26
EGRESS AREA
27
25d
FAILURE
26c
25a
27c
EGRESS
NODE
INGRESS
NODE
25e
LSP (NEWLY ADDED PATH)
LSP (MULTI PATH)
LOAD DISTRIBUTING POINT
FOR EACH TE PATH GROUP